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BULLETIN No. 116. MARCH, 1907.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT

STATION.

THE SAN JOSÉ SCALE

AND

EXPERIMENTS FOR ITS CONTROL

BY

H. T. FERNALD, Ph. D.

An account of the life history of the San José Scale; the injuries it causes; treatments for it; experiments for its control including chemical and practical studies of the lime-sulfur wash; a summary of experimental work in the United States; and full directions for making and applying the lime-sulfur wash.

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DIVISION OF ENTOMOLOGY.

The San José Scale and Experiments for its Control.

By H. T. FERNALD.

It is probable that all the towns in Massachusetts east of the Connecticut River, and many of those west are infested more or less with the San José Scale. First discovered in the State about 1892, it has become widely distributed since that time and has now increased to such an extent as to be one of our most serious pests. Indeed, in the opinion of many persons, it is even more dangerous than the Gypsy and Brown-tail Moths, for though it actually destroys fewer kinds of plants than the Gypsy Moth it is so small that its presence is rarely noted till the work of destruction is well-nigh completed. Its method of feeding, too, is such, taken in connection with its size, as to render successful treatment extremely difficult, and the rapidity with which it increases in numbers is often sufficient to cause the destruction of a tree in a single season.

Calls for information as to the appearance, life history and habits of this pest and the best methods for its control, at the present time form quite a large part of the correspondence of the Division of Entomology of this Station, and this bulletin has been prepared to answer these calls, and also to give the results of such experimental studies on control as have thus far been made here.

HISTORY.

The San José Scale is apparently a native of China, where it seems to be held more or less in check by a tiny lady bird or lady bug, *Chilocorus similis*, which feeds upon it. How it reached this country is not known but it was discovered in the San José Valley in

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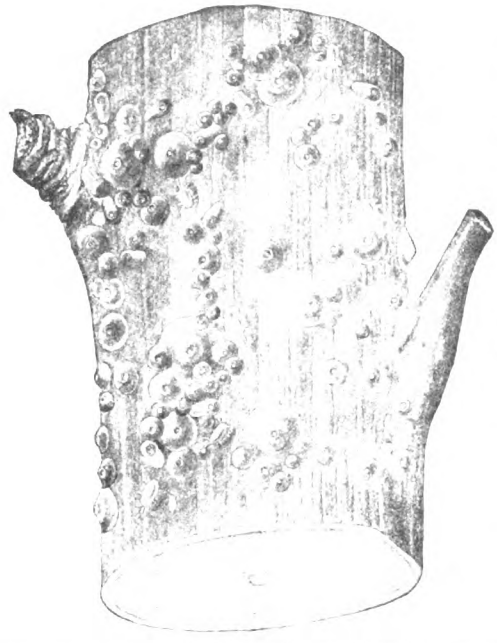
California about 1879 and was named *Aspidiotus perniciosus* by Prof. J. H. Comstock who wrote at that time of it:—"I think that it is the most pernicious scale insect known in this country." A few years later it was discovered in two New Jersey nurseries which had been sending out large quantities of stock, and on this stock it was undoubtedly distributed to nearly all parts of the United States. At first it seemed probable that it would not live or at least become a serious pest in the more northern states on account of the colder climate there, but it appears to have gradually become more hardy, and is now able to thrive in all parts of Massachusetts to a most unfortunate degree.

LIFE HISTORY AND APPEARANCE.



Different stages of the San José Scale enlarged five times (From Va. State Crop Pest Commission Bulletin, 1904.)

The full grown San José Scale is about the size of a pin head, quite flat, round (circular) in outline, and varying in color, but usually grayish brown. It lies closely against the bark, leaves or fruit and the part seen is not really the insect itself but the shell or scale which covers it. If this scale be lifted with a pin a very small, orange-yellow speck will be found beneath it, and this is the scale insect.

When winter sets in, the insects are present in all stages of growth from those just born to those which are full grown and are themselves producing young. The winter, however, kills all except those which are from about one-half to two-thirds grown, so that no living adults can usually be found in early spring.

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So far as is known these insects undergo no changes during the winter, but when the sap begins to flow freely in the spring the young scales which survive resume their feeding on the sap which was interrupted by the cold weather and complete their growth, becoming adult in June. Reproduction then begins, the young being born alive, and this continues for about six weeks, each female producing an average of about 400 young. The young insects are very small, and after their birth, crawl out from beneath the scale where they were born and move about, seeking a place on which to settle. This takes rather more than a day, on an average, and during this time these tiny, yellow, crawling young may be seen wandering about. On finding a good location they become quiet and each works its long beak through the bark, (or surface of the leaf or fruit as the case may be,) to where the sap of the tree can be obtained and the insect sucks this sap for its food. Its legs now disappear, its body becomes hemispherical, and white, waxy threads appear over its back. These mat together to form a white covering or scale, and such young, recently formed scales are often very noticeable. Later as the insect grows it molts or sheds its skin and the molted skin is added to the scale which because of this and by weathering becomes darker, grayish or even blackish, often showing rings of lighter and darker color. The center of the scale is the highest point and around this is a circular depressed ring. If the insect beneath the scale is a female the scale will remain nearly circular in outline; if a male, the scale is more oval or elongated in form. In a little more than a month from the time of its birth the insect becomes adult and in turn begins to produce young, the first ones appearing at about the same time as the last ones of the preceding generation. These young develop in the same way as did their parents, thus giving a constant succession of young from the middle or end of June, in Massachusetts, till winter stops the process.

It is evident that the increase in numbers of this insect is very great: estimates on this point show that an average of 1,608,040,200 females would be produced from a single female in one season, with probably at least an equal number of males, a total starting from a single female of 3,216,080,400 individuals! This estimate makes no allowance for loss by accidental destruction, but this is undoubtedly very great and is probably the main reason why we yet have any fruit trees alive, and it is fortunate that winter kills so many of the scales.

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FOOD PLANTS.

The San José Scale has been found on about 125 different kinds of trees, shrubs and vines. On many of these it will hardly more than exist and the chief danger in those cases is that such plants may serve as places from which to pass to others where it would be more destructive. Nearly all our fruit trees, however, are liable to destruction by this pest. It seems to cause the greatest injury in Massachusetts to the pear, plum, apple, peach, some varieties of cherry, and currant. Among ornamental shrubs and trees the Dogwoods, particularly the Red Osier, the Hawthorne and other thorns, the Japan Quince, poplars, ornamental cherries, plums and currants, roses, Mountain Ash, willows, the Hop tree and some kinds of Spiraea are often killed by it. This list includes almost all our fruit trees and more common ornamental shrubs and if to it we add those on which this pest will live and menace the more susceptible plants, it will be at once seen that the situation in Massachusetts is certainly a dangerous one. On fruit it produces unsightly discoloration, reducing its selling value. This condition was very noticeable on the fruit exhibits at fairs in the fall of 1906 and much of the fruit for sale in our markets shows the marks of the scale.

ENEMIES OF THE SCALE.

Several kinds of minute insects are parasitic on the scale, and a fungus lives upon it, but none of these appear to accomplish much in Massachusetts, the most effective foes here being a very small black beetle, *Microweisea misella* (Lec.), and a larger one, also black, but with two red spots on its back, these spots having given to the insect the name "Twice-Stabbed Lady Bug." These two beetles are active enemies of the scale but are not sufficiently abundant to hold it in check.

In its native country the San José Scale appears to be kept under control, as already stated, according to investigations made by the United States Department of Agriculture, by a lady bug very similar in appearance to our "Twice-Stabbed Lady Bug," and colonies of these insects have been brought to this country in the hope that they might accomplish similar results here. It is too soon to determine the success of this experiment, but thus far the results are not encouraging, particularly in the more northern states, like Massachusetts.

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HOW THE SCALE SPREADS.

This insect moves from one place to another only while in the crawling stage. At this time it may be caught by a gust of wind and carried from one tree to another, or it may crawl onto the feet of some bird or insect which has alighted on the infested tree and crawl off at some later resting place, which of course may be near by or more distant. In general, however, the scale is first brought to any locality on infested nursery stock and from this spreads to the neighboring trees and shrubs in one or another of the ways already mentioned.

TREATMENT.

When a tree or plant is nearly dead, the best treatment is generally to cut it down at the roots and burn it. Possibly it could be saved by the proper treatment, but it would be several years before it would recover sufficiently to be of any value. For trees less infested many methods have been tried. These naturally fall into two classes, fumigation and spraying.

FUMIGATION.

This in many regards is the most satisfactory method of treatment for infested trees. The poisonous gas penetrates where no spray could reach, and when properly managed kills all the scales. Unfortunately, it is not usually a practicable method in orchards and as a rule its use is limited to nursery stock. In order to fumigate successfully gas-tight tents must be used unless the trees are to be dug up; the chemicals must be of a definite strength, and the fumigation must be conducted by someone familiar with the process. The cost of tents large enough to cover orchard trees is usually prohibitive in Massachusetts.

SPRAYING.

The results of spraying for the San Jose scale made in 1902 at Amherst were given in Bulletin 86 of the Hatch Experiment Station, but as that bulletin is now out of print they are included here together with later work in the same line.

The first spraying was done between March 24th and April 5th, 1902. Six hundred and twelve trees were treated, the kinds being

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apple, pear, peach, plum, cherry, quince, apricot and nectarine. They ranged in size from nursery stock set the fall before to trees twenty feet or more high and spreading twenty-five feet.

Good's Caustic Potash Whale-oil Soap No. 3 at the rate of two pounds per gallon of water; Bowker's Tree Soap used at the same strength; Good's Caustic Potash Whale-oil Tobacco Soap at the same strength; Crude Petroleum mechanically emulsified with water, at percentages varying from 15% to 45%; Kerosene emulsified in the same way, at percentages varying from 18% to 38%; and Lime, Sulfur and Salt (lime 40 lbs., Sulfur 20 lbs.; Salt 15 lbs.; water to make 60 gallons) were the chief materials tested, though other things were tried to some extent. Of these the Lime, Sulfur and Salt Mixture gave the best results, followed by Bowker's Tree Soap. Crude Petroleum and Kerosene were quite satisfactory so far as killing the scale was concerned, but it has since been shown that after being sprayed with these oils a few times the trees are liable to be injured.

The Lime, Sulfur and Salt treatment gave such good results that it seemed well to experiment farther with it and study its properties. Accordingly a quantity of this substance was prepared and placed in the hands of Dr. Chas. Wellington of the Agricultural College, for qualitative and quantitative analysis, and to his kindness I am indebted for the following statement:

COMPOSITION OF THE LIME, SULFUR AND SALT WASH.

Substances.	Per cent. in Fresh Wash.	Per cent. after 12 hours.	Per cent. after 120 hours.
Calcium monosulfid and calcium hydrosulfid CaS and $Ca(SH)_2$.	25 to 30%		21 to 26%
Calcium polysulfids CaS_3, CaS_4, CaS_5.	3 to 5%		2 to 3%
Calcium hydrate $Ca(OH)_2$.	9%	8.5%	7%
Calcium carbonate $CaCO_3$.	1.8%	2.3%	2.8%
Calcium sulfite $CaSO_3$.	0%	1%	2%
Calcium thiosulfate CaS_2O_3.		0.5%	0.8%
Calcium sulfate $CaSO_4$.			0.2%

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In addition a little Iron sulfid was found, probably coming from the kettle in which the wash was prepared. The salt used did not seem to enter into any of the combinations.

Consideration of the results given above showed that the Calcium hydrate, Calcium carbonate and Calcium sulfate could at once be ruled out as having no insecticidal value.

To test the action of the remaining materials separately was the next step and again through the kindness of Dr. Wellington these were obtained though, owing to insufficient facilities for their production, it was only possible to supply them in quantities of ten gallons each. They were applied as follows:

Substance.	Per cent. Strength.	Per cent. of Lime.
Calcium monosulfid. CaS	6.02%	8.3%
Calcium hydrosulfid. $Ca(SH)_2$	5%	8%
Calcium polysulfids. CaS_3, CaS_4, CaS_5	4.05%	
Calcium polysulfids. CaS_3, CaS_4, CaS_5	4.05%	7.95%
Calcium sulfate. $CaSO_3$	11.2%	8.1%
Calcium thiosulfate. CaS_2O_3	7.15%	8.08%
Calcium thiosulfate. CaS_2O_3	14.08%	8.01%
Iron sulfid. FeS.	8.25%	8%

The process of manufacture of these substances was such that when they were obtained an excess of lime was also present in most cases, but as this would have been difficult to remove at reasonable expense and could hardly be a factor in the results, it was allowed to remain, the amount being shown in the last column of the above table.

Each of these eight substances was applied about the end of March, 1903, to from three to eight quite badly infested trees and the results were studied during the following spring and summer.

As was anticipated the Iron sulfid proved worthless as an insecti-

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cide and none of the other materials was as effective as the entire lime-sulfur mixture, but the applications were made to such a small number of trees in each case that the results can only be regarded as providing suggestive data for farther investigations along this line. With this in mind, however, the following conclusions were reached. The calcium monosulfid and calcium sulfite failed to improve the condition of any of the trees to which they were applied, and the hydrosulfid gave but little better results. The weak thiosulfate showed evidence of some insecticidal value and the strong thiosulfate benefited every tree to which it was applied. The polysulfids in which an excess of lime was present and those without it were of nearly equal value, the preference perhaps being slightly in favor of the latter, the results they gave being about like those obtained with the strong thiosulfate.

From this the conclusion was reached that the main insecticidal value of the lime-sulfur wash resides in the calcium polysulfids and the thiosulfate. Farther tests seemed desirable however before publishing these views, which have accordingly been held back for nearly four years, awaiting an opportunity for verification.

During this period one or two articles bearing on the subject have appeared, and the results given in them may here be touched upon. Haywood (Journ. Am. Chem. Soc., XXVII, pp. 244-255, 1905) finds only small quantities of calcium monosulfid, and thiosulfate at the beginning, the latter increasing with longer boiling, and he is of the opinion that polysulfids and a small amount of thiosulfate are produced at first but that on continued boiling the polysulfids gradually combine with oxygen to form thiosulfate and sulfur and that the thiosulfate also gradually changes, forming sulfite and sulfur. The sequence of the changes then, beginning with the polysulfids is that these oxidize forming thiosulfate and sulfur; that the thiosulfate decomposes, forming sulfite and sulfur, and finaly that the sulfite changes to sulfate.

The experiments already described, showed that the sulfite was not an insecticide, so that the interest in these changes centers on the polysulfids and thiosulfates.

Thatcher (Bull. 76, Wash. Ex. Station, 1906) goes farther than Haywood, claiming that "only two of these (substances), namely calcium pentasulfid and calcium thiosulfate are produced by the

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direct action of sulfur upon slaked lime." Though this is a rather sweeping statement and not entirely in accord either with Haywood's results or with the analyses made here, it nevertheless also brings these two substances forward as the insecticidal factors of the wash. In at least a general way then, the chemical work of Haywood and Thatcher sustains the conclusions reached on Massachusetts nearly four years ago.

If the calcium polysulfids or calcium thiosulfate are the insecticides of the lime-sulfur wash it still remains a question how they act. Results at this station pointed to both as being available, but the polysulfids oxidize quickly so that the benefit results on the trees sprayed with these substances were long likely to have really come from the thiosulfate into which they were soon converted.

Haywood mentions a suggestion that the action of the wash is caused by the production of sulphur dioxide, though he advances certain arguments against this views and also that it may be due to the finely divided sulfur set free during the oxidation. To the writer this last seems a more probable explanation, particularly when it is remembered that the sulfur thus liberated would be nascent sulfur and would probably possess powers not evident at other times, as the result of its nascent condition. It seems most likely therefore, that the efficiency of the lime-sulfur wash is due either to the direct action of calcium thiosulfate or to that of sulfur in a nascent condition.

To obtain the most effective lime sulfur wash it should, theoretically be so made as to contain the largest amount of calcium thiosulfate. This can be done by boiling the lime and sulfur for a long time, and a wash which is immediately active will be the result. This boiling, however, when long continued, obtains its larger amount of thiosulfate at the expense of the polysulfids which are oxidized. One of the valuable characters of the wash is the long period during which it acts, and it seems probable that this is due to the fact that as the stock of thiosulfate decreases it is renewed from the polysulfids which oxidize, forming more thiosulfate. From this standpoint therefore, it would seem wiser to use such amounts of lime and sulfur and boil them for such a time as to produce the largest amount of the polysulfids, which as they decompose would continually renew the stock of thiosulfate available. If nascent sul-

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fur is the active agent this last method of making would also be the best as nascent sulfur will be produced both by the oxidation of the polysulfids and the breaking down of the thiosulfate.

Turning to the question whether a long or a short boiling is the better, with these conclusions in mind it is at once evident that boiling for so short a time that the sulfur does not all enter into chemical combination produces a wash less effective than it should be. As examination of the sediment at the bottom of the kettle after boiling for half an hour has frequently shown that this consists to quite a degree of sulfur coated externally with lime, it is clear that in such cases the boiling has not been sufficient, and Haywood finds that it takes longer than this to dissolve all the sulfur.

The writer appreciates that the foregoing, together with what immediately follows is liable to criticism on the ground that the conclusions are drawn from too limited experiments, but in view of the fact that we have no more extensive tests in this line to make use of, the conclusions may at least have a tentative value and may be summarized as follows:

1. Take sufficient lime to combine with all the sulfur.
2. Calcium thiosulfate is the active insecticide and more of this is gradually formed by the decomposition of the polysulfids: therefore, boil to obtain as much of the polysulfids as possible.
3. Too long boiling produces more thiosulfates and free sulfur at the expense of the polysulfids present. The wash will be more active when first applied under these conditions but will not act during as long a time, and it is desirable that it should be active as long as possible.
4. Letting the wash stand after being made may perhaps give an opportunity for the polysulfids and thiosulfate to decompose in part, forming substances having no insecticidal value and thus reducing its effectiveness.
5. From the study of a large number of experiments it seems probable that forty minutes to an hour of actual boiling will be needed in order to obtain the greatest amount of the polysulfids.

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SELF-BOILING WASHES.

Perhaps the main objection to the use of the lime-sulfur wash is the necessity of boiling it, involving expense for a large iron kettle where steam is not available, and the time required. To avoid this, several self-boiling washes have been tested in different places. In all these tests some chemical has been added which would produce heat in the wash, to continue that produced by the slaking of the lime, sufficiently long to bring the lime and sulfur into combination without the use of a fire.

The results obtained in this way have been very variable. Sometimes they have been nearly or quite as good as those obtained by the use of a fire while sometimes they have been very unsatisfactory. The cost of the chemical added should of course be considered in tests of this kind, as well as the time required by this method as compared with that by the other.

In the spring of 1906 tests of sodic sulfid, caustic soda and sal soda as self-boilers were made at the Hatch Experiment Station. The formula used with the sodic sulfid was lime twenty lbs., sulfur ten lbs., sodic sulfid ten lbs., water forty gals. The sodic sulfid cost $3.20 per barrel of wash, the lime fourteen cents, and the sulfur twenty-eight cents, making the cost of the materials $3.62 per barrel of wash. The results obtained were only fair, many living scales being present on the trees at the first examination after treatment and becoming extremely abundant later.

The caustic soda treatment was made by taking lime twenty lbs., sulfur fourteen lbs., caustic soda five lbs., water forty gals. The caustic soda cost fifteen cents per pound, making the total cost for materials $1.28 per barrel of wash. The results were about like those with the sodic sulfid.

The same formula substituting sal soda for caustic soda cost eighty-seven cents per barrel for the materials and gave better results than either of the others though not as good as those obtained from the boiled lime-sulfur wash which cost about fifty cents per barrel for the materials. The time taken by the self boiling washes averaged about a half an hour per barrel, so that the amount of time actually saved by this method was less than had been anticipated.

These results are not as good as some which have been reported but represent a fair average of them as given from all parts of the

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United States, and the conclusions they warrant would be that, considering the higher cost of the self boiling washes, the small amount of time they save in preparation, and their reduced effectiveness in most cases, offset only by the fact that no kettle to boil in is needed, these self boiling mixtures are not a success and should only be recommended where such a small number of trees is to be treated that the expenditure of fifteen dollars or so for a kettle would be unwise.

THE K-L MIXTURE.

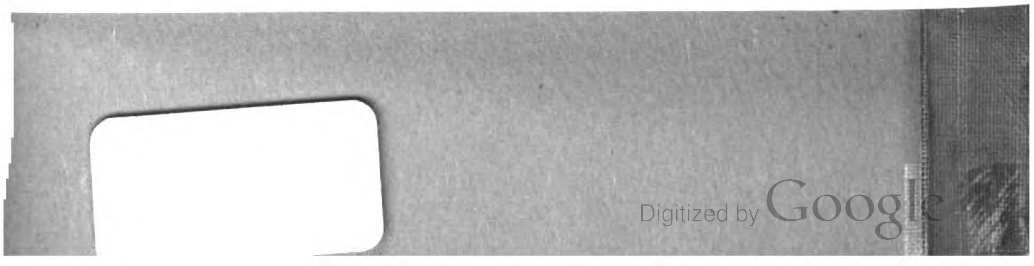
This material has been highly recommended by the Delaware Experiment Station and has been tested at a number of places. It was tried here last spring, the formula used being—limoid 3 3/4 lbs., kerosene 8 1/3 gals., water 25 gals. The limoid cost one and a quarter cents per pound in barrel lots in Delaware, the nearest place at which it could be obtained, and the kerosene at that time cost eleven cents per gallon, making the cost of the materials $1.34 per barrel besides the freight charges.

It was found quite difficult to produce a satisfactory emulsion of the materials, considerable time being needed, and the results on the scales were far from satisfactory, the trees being badly infested again as early as July twenty-first, while others all around them, treated with the ordinary lime-sulfur wash costing about one-third as much, were in excellent condition.

This is the result of only one test, but so far as it goes, it would lead the writer to hesitate to advise the use of the K-L mixture.

SUMMARY OF EXPERIMENTAL WORK IN THE UNITED STATES.

The San José Scale has probably been the subject of a larger number of tests of treatment in this country than any other insect, over five hundred separate experiments having been published. To summarize these is a difficult and perplexing task, but has been undertaken in the hope that at least a few general facts might be brought to light, and the following statements represent what has been found.



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Potash Whale-oil Soap at the rate of two pounds per gallon of water is a fairly good winter treatment though more expensive than some others. As no boiling is needed it is quite convenient to prepare. Among the best Whale-oil soaps on the market are Bowker's Tree Soap, Good's Caustic Potash Whale-oil Soap No. 3 and Legge's and Bro's. Anchor Brand. The addition of tobacco seems to be somewhat beneficial but at an additional cost.

Soda Soaps so far as tests of them have been observed seem to be much less effective than the Potash soaps.

Crude Petroleum and Kerosene have generally given fair results as far as killing the scale goes, when thoroughly applied, but the effect on the trees has often been serious and these materials are in consequence not held in great favor, as in addition to this objection they are more expensive than other and better materials now in use.

The K-L Mixture is a recent addition to the list of materials and the results obtained from its use have been very variable, some being excellent and others poor. It is difficult to obtain a satisfactory mixture of the materials, and the cost is considerably greater than with other treatments. From these facts it is hardly likely that it will come into general use.

Bordeaux, sulfur and soda mixture first used on the Pacific coast and now in general use throughout this country have been made according to many different formulas, but the results when certain factors were given due attention, have been very satisfactory. The soda which was at first considered an important ingredient is now generally omitted, the earlier idea that it added to the adhering power of the wash being for the most part rejected. What the nature of the action of the wash is has not been understood and in consequence the length of time it was necessary to boil it, and the amount of each ingredient to use have been unknown.

From what has already been stated it seems probable that the amounts of lime and of sulfur taken, and the time they are boiled should be such as to produce the greatest amounts possible of the higher sulfids, and to obtain these the writer is of the opinion that for fifty gallons of water about twenty-two pounds of lime and twenty pounds of sulfur boiled together for from forty minutes to an hour will be likely to give the greatest amount of the desired sulfids and correspondingly the best results. An interesting series of experi-

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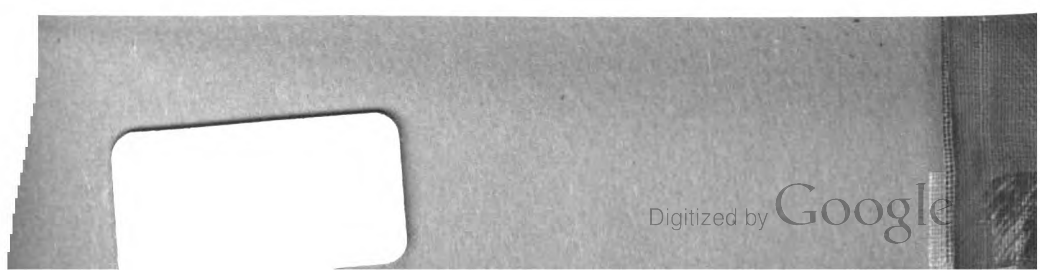
ments which does not as yet seem to have been consistently made would be to prepare washes using fifteen, twenty, twenty-five and thirty pounds of lime to fifteen pounds of sulfur, boiling in each case for the same length of time; a similar series wherein the amount of sulfur should be the variable factor; a third series in which for each combination of lime and sulfur the time of boiling should vary and a fourth in which the amount of water used during the boiling should be the varying factor, as it is possible that this has something to do with what might be termed the "opportunity" the materials would have to combine in different ways. It has been noticeable, in comparing the results obtained in different parts of the country, that in general the best results have been reported where quite large amounts of lime and sulfur have been taken and the boiling has been for at least three-quarters of an hour in a considerable amount of water.

The cost of the materials for the lime-sulfur wash is less than for any of the other sprays thus far considered, and the drawback it has is the cost of apparatus for boiling and the time required.

Self-boiled Washes have been quite widely tested to avoid the difficulty just mentioned, caustic soda, sal soda or sodium sulfid being added to continue the boiling begun by the slaking of the lime and thus produce the chemical combinations desired. The cost of a boiling apparatus is saved in this way but that of the chemical added in part offsets this and the results have been very variable, due probably to a more or less partial failure to obtain sufficient heat for a sufficient length of time. While excellent results have occasionally been reached the average of the reports indicates that this method fails to equal the results from the boiled wash.

Blue Vitriol added to the boiled wash has been tested with some apparent success, but Thatcher finds that this combines with the higher sulfids rendering them insoluble and the value of this wash on the theory of its action given above would then depend entirely upon the thiosulfate present at the time of application.

Miscellaneous materials mainly in the form of "Proprietary Insecticides" have been placed upon the market in great numbers and many of them have proved to be of no value whatever, so far as tests show. The more important of these and the average results given by their use follow.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Calcothion, a ready made lime-sulfur wash has given good results but is expensive.

Rex Lime and Sulfur Solution has proved to be of some value, but not as efficient as the boiled material. Made in Omaha, the cost of obtaining it in the east, added to its price which will be about $12.50 per barrel at retail would probably be too great to admit of its general use in this locality.

Consol which is more or less of a lime-sulfur mixture does not seem to be of much value, judging from such tests of it as have been noticed.

Horicum. Reports on this material vary from fair to poor in the results which have been met with in preparing this summary.

Caustic Soda applied at the rate of one pound in six gallons of water was widely recommended at one time, but uniform failure to destroy the scales at this strength or at any strength unless used strong enough to injure the buds also, has led to dropping this substance.

Kil-O-Scale. A number of tests with this substance indicate that it is not always an entirely satisfactory material, though the best reports state that a large per cent of the scales was killed.

Scalecide. This so-called "soluble oil" which is really a mixture of distillate oil of petroleum, a vegetable oil and resin oil according to the statements of persons interested, has obtained very variable reports in different tests. Applied at the rate of one gallon to twenty gallons of water it does not seem to be particularly effective, but at the strength of one to twelve or one to fifteen, when applied twice under pressure of one hundred pounds or more at the nozzle it seems to be a very effective spray. It may perhaps be termed at the present time a promising insecticide.

Target Brand Scale Destroyer appears to be somewhat similar to Scalecide in many ways, and the results obtained from its use have been quite good in some cases, though when applied at the rate of one gallon to twenty gallons of water the results have not been entirely satisfactory. The reports seen would place this material below Scalecide in effectiveness.

After a careful study of all the reports on Scalecide and Target Brand Scale Destroyer available, together with some personal expe-

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rience, the writer is of the opinion that aside from the lime-sulfur wash these are probably the most promising materials now on the market, of which he has knowledge. To obtain success with them however it seems necessary to apply them as strong as one part to fifteen of water, under great pressure at the nozzle, and to be very thorough in the application. The lime-sulfur wash applied under similar conditions will do as good and perhaps even better work, while used with less care but under the same exact conditions the lime-sulfur wash gave better results. The writer would therefore advise the use of Scalecide or Target Brand Scale Destroyer only where it is not possible to make the boiled lime-sulfur wash, and where a thorough application under the conditions named can be given.

Other materials which have been tested and which have either given poor results or were worthless so far as these reports go, for the purpose of destroying the San José Scale are, Naphein, Fruitolin, Surekil, Tak-a-nap Soap, San José Exterminator, Webcide, Standard Disinfectant, Ska-kil, Derror Tree Fluid, Bordeaux Mixture, Whitewash and Crude Carbolic acid. Undoubtedly many others are on the market, but no reports of their value are at hand.

Conclusion. From what has been written it follows that where a kettle or steam for boiling is available the lime-sulfur wash properly prepared is the most satisfactory and probably the cheapest material to use. Scalecide or Target Brand Scale Destroyer would naturally be chosen if boiling is for any reason impracticable, and perhaps in some cases would be preferable on account of the trouble to boil where only a few trees or shrubs are to be treated. It should be stated that only the statements of State and Station officials have here been considered in preparing this summary.

Recommendations. Where any considerable amount of spraying is to be done, use the lime-sulfur wash prepared according to directions given below. Where only a few shrubs or trees are to be treated, or where for any reason boiling is not practicable, use Scalecide or perhaps Target Brand Scale Destroyer at the rate of one gallon of the material to fifteen gallons of water, well mixed, applied twice—preferably late in the fall and again early in spring before the buds open—with as great pressure at the nozzle as posssible, and applied very thoroughly so that every twig even may be covered by the spray.

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HOW TO MAKE THE LIME-SULFUR WASH.

The lime used in making the wash must be good stone lime. Magnesia lime is not desirable, which is as fresh as possible. Where the lime has air slaked to any degree results are far less satisfactory. The sulfur should be Flowers of Sulfur or Sulfur flour, the former being the better for the purpose.

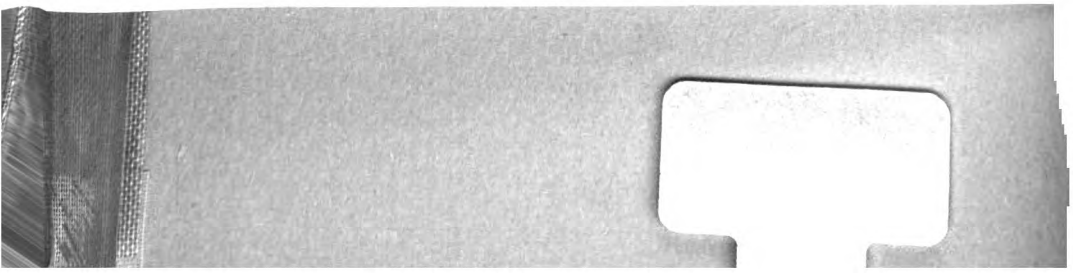
Place six or eight gallons of water in the kettle, start a fire under it, and slake the lime (22 lbs.) getting this as fine as possible in the slaking. When this is well under way gradually add the sulfur, (22 lbs.) stirring it in well, and keep the fire going to continue the heat begun by the slaking lime. Keep the mixture boiling, adding water (preferably hot) from time to time, till it has boiled at least forty minutes and is dark orange red in color. If there seems to be a considerable amount of sediment at the bottom of the kettle this may be taken as an indication, either that the boiling has not continued long enough or that the lime was not of very good quality. When the boiling has been completed strain the liquid into the spray pump barrel through a strainer of copper wire of at least twenty threads to the inch, and add whatever water may be needed to make the fifty gallons or thereabout, which the barrel holds. Then spray at once, as in many cases where a lot of the wash has been made one afternoon and sprayed the next morning it has proved less effective, due probably to chemical changes which took place while it was standing.

That this method of making the wash is inconvenient to say the least, is evident, and experiments which may show that we can do away with the necessity for any boiling are in progress, but the results are not yet available, though it is hoped that they may prove successful.

HOW TO SPRAY FOR THE SCALE.

Every scale must be touched by the spray in order to be killed, but a very small droplet on each will be sufficient. To spray successfully then, *spray thoroughly*.

There are numerous pumps on the market which work well for the purpose. Those which have happened to be used at the Massachusetts Experiment Station, and which were entirely satisfactory, were the "Pomona" and "Fruitall," made by the Goulds Manufacturing Co. of Seneca Falls, N. Y., and the "Hardie" Pump, made by the



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Hardie Manufacturing Co. of Hudson, Mich. All working parts of the pump should be of brass or bronze.

From the pump one or two lines of hose can be run as may be most convenient. Each should be joined to an extension rod with a "shut off" valve at its base. At the end of the extension rod a "Y" should be connected and a nozzle placed at the end of each arm of the "Y". The best nozzle is one which will throw a fine mist, as even then one droplet should be sufficient for each scale, and by turning the two nozzles so that they will spray in different directions the tree can be much more quickly covered. Eight or ten different kinds of nozzles have been tried in the course of this work at Amherst, but the best results in the way of thoroughly covering the tree with the least waste of material were obtained with nozzles of the Vermorel type, and of these the "Mistry" has been the most satisfactory.

If the trees can be well pruned before spraying much extra time and trouble will be saved as the most difficult parts of a tree to cover well are the smaller twigs. In spraying it is well to begin at the top and work downward, rapidly following each branch toward the trunk with the nozzles, and if there is a wind, working on that half of the tree which is to windward. If there is little or no wind, the tree can be treated from all sides before it is left, but with much wind blowing it may be better to spray all the trees from one side only, treating the other side as soon afterwards as the weather will permit. It must be remembered however, that the object is to cover every particle of the surface *everywhere* with the spray. As the wash shows plainly when it dries this can often be taken advantage of to "touch up" later any spots which were missed at first. In spraying, pump so as to put on as much pressure as possible, and hold the nozzles as near the branches as can be done, to drive the mist into all the tiny crevices in the bark under which the scales appear to like to conceal themselves.

Treatment as thus directed will usually result in the larger limbs and trunk being more or less soaked by surplus spray which runs down from above, but this should do no harm and in fact is likely to be advantageous.

WHEN TO SPRAY.

It is generally considered unsafe to spray for the San José Scale while the leaves are on the trees, the materials used are so strong:

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though in certain cases trees have been sprayed when in full leaf in June, with the lime sulfur wash without the slightest injury resulting. Treatment in summer is not advisable, however, and the best and safest time to apply the wash is from the time the leaves have fallen till the buds begin to open in spring. Where the trees are badly infested two treatments — one late in the fall and the other early the next spring — are most desirable, but where only one is needed or possible for any reason, the results obtained in Massachusetts point to the spring as the time when the best results are to be obtained.

SUMMER TREATMENT.

In case trees are found during the summer which are so badly infested that it seems probable they will die before winter, a mild treatment to hold the scales in check is needed. It is not safe to use the treatments already discussed, at this time of year and the best material under the circumstances is one of the Whale oil soaps at the strength of one pound of soap to five gallons of water.

This will destroy all the crawling young it reaches and thus prevent as rapid increase in numbers of the scale as would otherwise be the case. The treatment may need to be repeated several times however, as the old scales are not affected and more young will be constantly appearing. Spraying at this time is particularly unsatisfactory too, as the leaves render it difficult to cover the twigs and branches as thoroughly as is desirable.

SUMMARY.

1. The San José Scale is present nearly everywhere in Massachusetts and is causing great injury and financial loss.
2. Its life history is such that enormous numbers of individuals are quickly produced.
3. It feeds on about 125 different kinds of plants including our most important fruit trees and ornamental shrubs.
4. None of its enemies seem able to keep it under control in this state.
5. Treatment of the plant affected varies according to its condition. If nearly dead, cut it down and burn it. If less seriously affected, fumigation is the best treatment, but this is not usually practicable except for nursery stock.

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6. Spraying experiments at this Station and almost everywhere in the United States show that the lime-sulfur wash gives the best average results.

7. The insecticide in this wash is probably either calcium thiosulfate or nascent sulfur produced as the materials present break up chemically.

8. Long boiling of the wash (45 minutes to one hour) has given better average results than boiling for half an hour or less.

9. Letting the wash stand for a day after it has been made is not safe, though exceptions where good results under these conditions are obtained, are frequent.

10. Self-boiling washes are sometimes fairly successful but good results cannot be safely counted on.

11. The K-L Mixture has not proved a success at Amherst and in many other places. It is very expensive as compared with the lime-sulfur wash.

12. A summary of the experimental treatments for the scale, made in this country, indicates that there is nothing better than the lime-sulfur wash where boiling is possible.

13. Where boiling is impossible or where only a very few trees are to be treated, Scalecide used under certain conditions named, may prove a satisfactory substitute.

14. Most of the "proprietary insecticides" for the scale are either pure "fakes," give poor results, or are so expensive as to be unprofitable to use.

15. Directions for making the wash, and how and when to apply it are given fully.

16. Summer spraying with whale-oil soap will often hold the scale in check till winter applications can be made.

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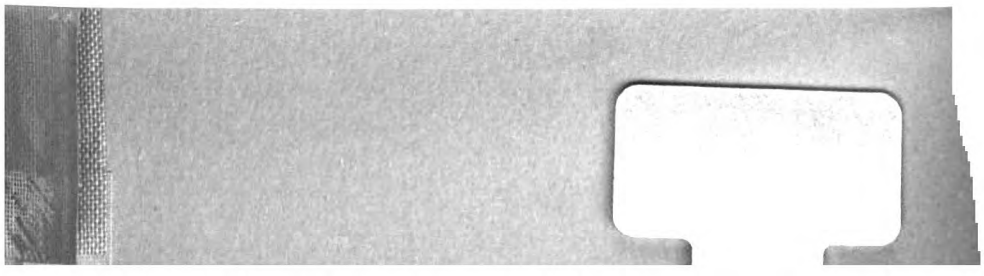

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